IDA MEMORANDUM REPORT M-409

Ada PROGRAM MANAGER ISSUES

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JUL 11 1990
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December 1987

Prepared for
Ada Jcint Program Office

INSTITUTE FOR DEFENSE ANALYSES
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1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE December 1987	3. REPORT TYPE AND DATES COVERED Final

4. TITLE AND SUBTITLE
Ada Program Manager Issues

5. FUNDING NUMBERS
MDA 903 84 C 0031
T-D5-306

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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Alexandria, VA 22311-1772

8. PERFORMING ORGANIZATION REPORT NUMBER
IDA Memorandum Report
M-409

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Ada Joint Program Office (AJPO)
Room 3E114, The Pentagon
Washington, D.C. 20301-3081

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, unlimited distribution.

12b. DISTRIBUTION CODE
2A

13. ABSTRACT (Maximum 200 words)

IDA Memorandum Report M-409, Ada Program Manager Issues, presents the findings of an investigation undertaken by the Institute for Defense Analyses (IDA) for the Ada Joint Program Office (AJPO) to determine if there is an unfulfilled need for AJPO assistance to project managers of major Ada software developments. The information provided in this report is intended to provide the AJPO with a indication of assistance that is available and used by managers, and an indication of how well this assistance matches the need. the investigation was limited in scope, that is, by time and effort, to quickly determine if there are major problems that should be investigated further.

14. SUBJECT TERMS
Ada Programming Language; Software Programs; Ada Technology Insertion; Software Engineering Institute (SEI); Army Light Helicopter (LHX); Real Time.

15. NUMBER OF PAGES
18

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT SAR

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PREFACE

This document reports the results of a preliminary investigation of reported issues that Ada program managers have encountered. This investigation was undertaken by IDA for the Ada Joint Program Office (AJPO) in partial fulfillment of IDA Task T-D5-306. Reviewers were Dr. Robert Winner, Dr. Joe Linn, and Ms. Audrey Hook.

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1. Introduction

This report presents the findings of an investigation undertaken by IDA for the Ada Joint Program Office to determine if there is an unfulfilled need for AJPO assistance to project managers of major Ada software developments. The information provided in this report is intended to provide the Ada Joint Program Office (AJPO) with an indication of assistance that is available and used by managers and an indication of how well this assistance matches the need. This report partially fulfills requirements of IDA task T-D5-306, Ada Technology Insertion.

2. Scope

The investigation was limited in scope (i.e., time and effort) to quickly determine if there are major problems that should be investigated further. Discussions were held with members of the software engineering staff at the Software Engineering Institute (SEI) concerning their knowledge of Service Ada project needs and with both contractors who are developing Ada software for the Army Light Helicopter (LHX). (The size of the LHX software effort, estimated to be in excess of 2,000,000 lines of source code, and the requirements for real-time, distributed, fault-tolerant mission equipment performance make the LHX a major Ada software development program.) Several documents produced by the SEI and the International Workshop on Real-Time Issues were also reviewed to obtain an overview of the program management help that is available or issues that are unresolved.

3. Findings and Discussion

The findings are presented in three sections—those dealing with Ada project management, those dealing with Ada usage, and validation policy. Management findings relate to the resources that are available for solving project management problems. The Ada usage finding relates to perceived implementation problems: the policy finding relates to the lack of policy for validation of hardware simulators.

3.1 Management Findings

Finding: Two Air Force studies of Ada project manager needs have resulted in documents that address these needs.

Discussion: The Air Force has already commissioned at least two studies of program management problems related to using Ada. One study was performed by SEI and is reported in "Ada Adoption Handbook: A Program Manager's Guide,"[1] the other was commissioned by ESD and is summarized in "Program Office Guide to Ada."[2] The author has reviewed both documents and finds them to be informative and valuable sources of information about issues of interest to project managers. A handbook or program office guide for each Service, similar to the one developed by the Air Force, would be useful to provide general Ada guidance and Service specific information.

Finding: Program managers have encountered life cycle management problems.

Discussion: During a visit to the SEI, the author learned that members of the SEI staff have been asked to help resolve perceived technical problems with several military projects. These problems fell into a pattern of design deficiencies that led the people at SEI to infer that these problems were symptoms of poor software engineering and weak management. People who had participated in SEI assistance teams also expressed the opinion that earlier participation in system design reviews by independent software design review teams might have prevented many of the implementation problems that appeared insurmountable to the project manager. Although DoD-STD-2167A and MIL-STD-1521B provide for early review of the system requirements, design and specification, the experience of the SEI staff indicates that sometimes these reviews are not sufficient to identify fundamental weaknesses in the software design. In large development projects, it is often a major achievement to be able to recognize that a problem exists and to classify the problem. Prototyping can help uncover faulty design before there are implementation problems that make it more difficult to recognize a design problem. Once a problem has been recognized and classified by the project manager, the AJPO may be a resource for advice on particular aspects of the problem. For example, if the problem concerns compiler design or the performance of the run-time system, the AJPO may coordinate meetings between the compiler developer and the project manager, or may advise the project manager to obtain the Ada Compiler Evaluation Capability (ACEC), or may identify another project manager who has solved similar problems. If, however, the program is attempting to incorporate a design that is fundamentally flawed, then neither Ada, the AJPO, nor any panel of experts can prevent the design team from encountering problems.

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1. John Foreman and John Goodenough, "Ada Adoption Handbook: A Program Manager's Guide," Technical Report CMU/SEI-87-TR-9 ESD-TR-87-110, May 1987.

2. C. N. Ausnit, E. R. Ansarov, and N. H. Cohen, "Program Office Guide to Ada, Edition I," ESD-TR-86-282, 17 September 1986.

Finding: The LHX contractors expressed satisfaction with the AJPO program guidance.

Discussion: The LHX software design teams were pleased with the response and support that they received in obtaining compilers for their designs. Both designs included use of the MIL-STD-1750A computer standard on a hardware that was not yet available. Although such a situation could raise a problem in obtaining a validated compiler for the target system, such problems were avoided through use of a compiler that was validated by simulation. The AJPO guidance to use a simulator to validate the compiler for the MIL-STD-1750A target was essential for the LHX program.

Finding: The LHX contractor teams have access to groups of experts for problem solving.

Discussion: Both teams of LHX contractors said that their parent companies had established connections to a network of experts who could be consulted for problem solving. The experts were used to review design decisions, to gather information about hardware and software design trends, and to serve as a mechanism for reporting troubles. The networks involved both a private consortium and a government agency, Microelectronics and Computer Technology Corporation (MCC) and Joint Integrated Avionics Working Group (JIAWG).

3.2 Usage Issues

Finding: Ada is being used for real-time embedded computer systems, with a distributed architecture, but implementation requires "work-around" techniques.

Discussion: Like most languages, Ada is an imperfect match for programs based on monitor-style concurrency control or the object-oriented programming paradigm.[3] However, program developers have developed techniques for working with the language to implement their designs. After learning the language, software developers appreciate the software engineering features of the language, but to attain the necessary performance, they restrict the use of certain features:

   a.   tasking and rendezvous for distributed processing,

   b.   exceptions—except for fatal conditions, and

   c.   dynamic allocation.

Both LHX development teams see the need for a "distributed-system" operating system to provide for interprocess communication, fault detection, and reconfiguration. One of the teams selected a particular compiler vendor and specified the semantics of run-time system interfaces. This team said that they would replace run-time system code with assembly code if necessary to achieve performance improvements.

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3. Joseph L. Linn, Cathy Jo Linn, Cy D. Ardoin, "Improving Ada for Use in Embedded Systems and System Programming," IDA Paper, to be published in March 1989.

One of the LHX developers expressed an opinion that if Ada is not changed to make it more suitable for real-time distributed fault tolerant applications, then it will cease to be a viable alternative for weapon systems. The International Workshop on Real-Time Ada Issues, at the May 1987 meeting, identified 10 features that Ada should support.[4] Research is being conducted on these topics within the SEI and by participants in the Real-Time Ada Issues working groups.

3.3 Policy

Finding: There is no formal procedure for validating the simulation of the MIL-STD-1750-A.

Discussion: Although use of a simulation was essential for early validation of the compiler for programs that are using the 1750A architecture as a target, the simulation itself has not been subjected to a validation that is equivalent to the compiler validation. Without such a rigorous validation of the simulation, it may be possible to encounter problems with validated compilers when the hardware becomes available.

4. Conclusions and Recommendations

During this investigation, program management assistance resources were found to be available and examples of their use by managers of large Ada software development indicate that the issue is early detection and classification of a problem. The program management problems were not specific to usage of the Ada language but rather to a lack of software engineering and project management experience. Software engineering education and experience in applying software engineering principles using Ada may be the most significant problem area that requires attention from the Services. Ada usage problems are being addressed by research and the application of engineering solutions known as "work-arounds". Information concerning these engineering solutions is being shared with participants in the working groups who are interested in them. The development community has not reported problems that preclude using Ada for the next generation of weapon systems although some members of both the development and research communities expect to participate in the language revision process to express their views of how the language should be changed so as to minimize implementation problems. The use of simulation models of hardware enables software development with a validated Ada compiler. A policy on the validation of simulated hardware target systems, particularly for a MIL-STD target computer, is needed to reduce the risk that the compiler and developed code will be unusable when the real hardware is delivered. The following recommendations apply to the AJPO in its DoD role:

1. Continue to emphasize the use of prototyping in the software development life-cycle.

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4. Periodic tasks, sporadic tasks, fault tolerance, distributed systems, time abstraction, reconfiguration, dynamic binding, resource utilization, concurrency, and traceability.

2. Encourage all DoD components to develop project manager handbooks.

3. Encourage all DoD components to institutionalize independent software design reviews during the early stages of system acquisition.

4. Continue support for Ada education and training.

5. Encourage the Air Force to develop a policy for the validation of simulations of the MIL-STD-1750A.

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